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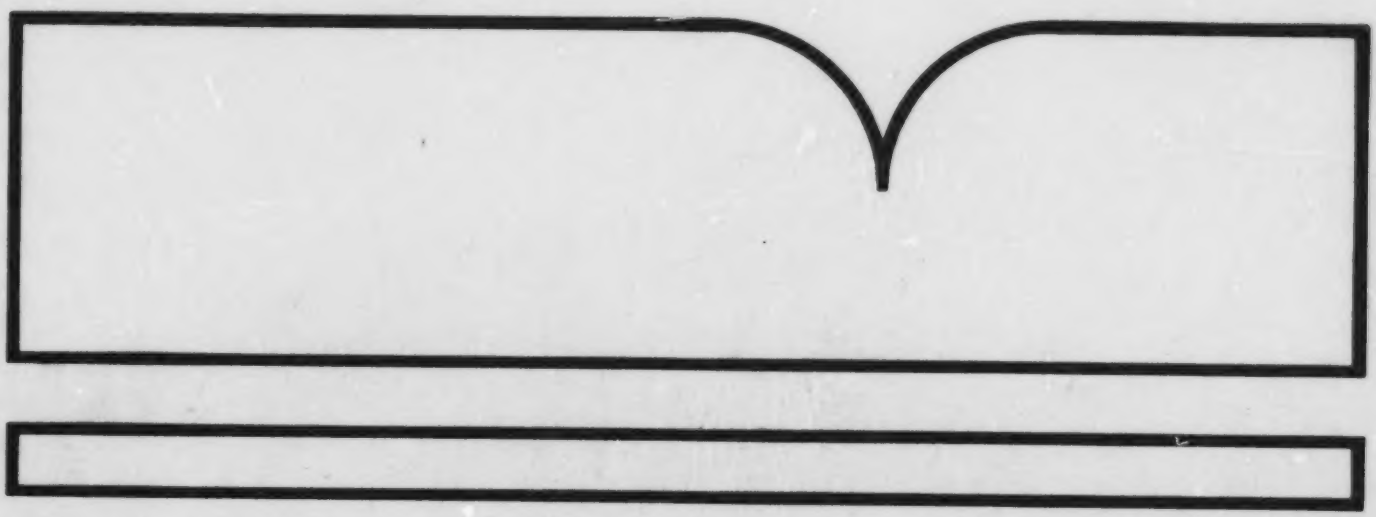

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Proceedings of the Joint Symposium on Stationary Combustion NO_x Control

Volume I

NO_x Emission Issues

and Invited Papers

Symposium Cochairmen
Robert E. Hall, EPA
and
J. Edward Cichanowicz, EPRI

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PREFACE

These proceedings document more than 50 presentations given at the Joint Symposium on Stationary Combustion NO_x Control held October 6-9, 1980 at the Stouffer's Denver Inn in Denver, Colorado. The symposium was sponsored by the Combustion Research Branch of the EPA's Industrial Environmental Research Laboratory-Research Triangle Park and the Electric Power Research Institute (EPRI). The presentations emphasized recent developments in NO_x control technology. Cochairmen of the symposium were Robert E. Hall, EPA, and J. Edward Cichanowicz, EPRI. Introductory remarks were made by Dan V. Giovanni, Program Manager for Air Quality Control, Coal Combustion Systems Division, EPRI, and the welcoming address was given by Roger L. Williams, Regional Administrator, EPA Region VIII. Stephen J. Gage, Assistant Administrator for Research and Development, EPA, was the keynote speaker. The symposium had 11 sessions:

I: NO_x Emissions Issues
Michael J. Miller, EPRI, Session Chairman

II: Manufacturers Update of Commercially Available Combustion Technology
Joshua S. Bowen, EPA, Session Chairman

III: NO_x Emissions Characterization of Full Scale Utility Powerplants
David G. Lachapelle, EPA, Session Chairman

IV: Low NO_x Combustion Development
Michael W. McElroy, EPRI, Session Chairman

Va: Postcombustion NO_x Control
George P. Green, Public Service Company of Colorado, Session Chairman

Vb: Fundamental Combustion Research
Tom W. Lester, EPA, Session Chairman

VI: Status of Flue Gas Treatment for Coal-Fired Boilers
Dan V. Giovanni, EPRI, Session Chairman

VII: Large Industrial Boilers
J. David Mobley, EPA, Session Chairman

VIII: Small Industrial, Commercial, and Residential Systems
J. David Mobley, EPA, Session Chairman

IX: Environmental Assessment
Robert P. Hangebrauck, EPA, Session Chairman

X: Stationary Engines and Industrial Process Combustion Systems
Robert E. Hall, EPA, Session Chairman

XI: Advanced Processes
G. Blair Martin, EPA, Session Chairman

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INTRODUCTORY REMARKS

Dan V. Giovanni, Manager
Air Quality Control Program, EPRI

It is my pleasure today to welcome you on behalf of EPRI to the Joint Symposium on Stationary Combustion NOx Control. This is the third in a series of symposia with which EPRI has been associated and it may prove to be the most important.

NOx emissions from stationary sources have been controlled to date through manipulation of the combustion process using conventional furnace and burner designs. To achieve significantly lower NOx levels it will be necessary to employ heretofore unconventional combustion systems or post-combustion treatment processes. New technologies such as these inherently increase the risks undertaken by manufacturers and operators of stationary combustion equipment. Capital and operating costs will increase and overall system reliability may be jeopardized.

To help offset these risks, successful research and development programs are necessary. During the next few days we will be hearing and discussing results from ongoing EPRI and EPA projects, as well as, many private programs undertaken in the U.S., Japan, and Europe. I encourage your active participation in the symposium. Thank you.

WELCOMING ADDRESS

Roger L. Williams, Regional Administrator, VIII
U.S. Environmental Protection Agency

Good Morning. It is my pleasure to welcome you to Denver and to this symposium on nitrogen oxides control. The joint sponsorship of this symposium by the Electric Power Research Institute and the Environmental Protection Agency provides the clear message of the need and desire for a close working relationship between energy and environmental interests. Later this week another workshop will be held here in Denver that will have a broader theme, designed to assist the Energy Community in understanding the many programs and authorities administered by the EPA. This seminar beginning on Wednesday is titled, "Conference on Environmental Regulations Relating to Energy."

Hardly a week goes by that there isn't a major energy conference or workshop here in Denver. Estimates indicate that there are more than 600 energy companies now residing in Denver. Denver is rapidly becoming known as the "Energy Capital" of the West. The development of Western United States vast energy resources is a vital ingredient in the National Energy Plan. EPA is committed to doing its part in support of the Nation's goal of energy self-sufficiency. These cooperative workshops are an important part toward that end.

Conversion of oil and gas fired utility boilers to coal is an important part of the energy supply equation and should proceed expeditiously. Almost 3 million barrels per day of oil equivalent could be displaced. Conversion of industrial boilers where possible should also proceed. EPA's role under the Power Plant and Industrial Fuel Act of 1978 and the Clean Air Act Amendments of 1977 is one of assuring that these conversions occur in an environmentally acceptable manner. Continued research into cost effective methods to reduce NOx emissions from stationary source combustion, such as papers presented at this symposium are a key to the environmental acceptance of these conversions.

All new steam electric power plants constructed in the United States will be coal fired or nuclear. The abundance and availability of cheap surface mineable coal in the West has provided an attraction for the utility industry. This attraction has resulted in a substantial increase in EPA Region VIII Office activities in the form of EIS reviews, issuance of surface water discharge permits, and air quality (PSD) permits to construct and operate. Since January 1, 1978 we have issued more than 308 energy related permits. We are presently averaging one Regional energy related action per working day and this pace is projected for the next five years. Most permitting applications have been approved with reasonable environmental safeguards, a few permits have been denied. Since the PSD concept was adopted in the Clean Air Act Amendments of 1977, my Office has received applications for and issued PSD permits to eleven power plants with a total combined generating capacity of almost 10,000 Megawatts. This will raise the Rocky Mountain Regions generating capacity to about 29,000 MW. I believe that this indicates that while environmental standards impose tough requirements in the form of new source performance standards, best available control technology, and PSD ambient air quality increments, the program cannot be labeled as a major inhibiting force against energy development as some people have chosen to do. Appropriate siting combined with good controls result in adequate energy development coupled with proper environmental protection.

The protection of environmentally sensitive areas must share an equal place at the table along with the development of energy resources. Region VIII states have been blessed with a dichotomy. While we have abundant energy resources -- 50% of the Nation's coal and uranium resources and essentially all of the oil shale and tar sands resources -- we also have the cleanest air and water in the Nation, 10 million acres of Class I National Parks and

Wilderness areas, wild and scenic rivers, unique wetlands, prime agricultural land, endangered species and habitat and some of the Nation's clearest visibility. It is heartening to see increasing emphasis on energy conservation measures and on the development of renewable energy resources. It is also encouraging to note that electric power demand increased by only 2.1 percent in 1979 over 1978. That is a major improvement over the industry's historic 7 percent annual growth rate.

It is clear from a review of your program and the experience assembled in this room, that this conference will be a major success and have a significant impact in the field of combustion research and environmental control.

We are very pleased to have the opportunity to co-sponsor this seminar with the Electric Power Research Institute here in Denver and look forward to the continued cooperation between your Industry and EPA towards a better life.

Welcome and I wish you much success for your seminar.

Thank you.

SOLVING THE NO_x CONTROL DILEMMA
(Keynote Address, October 6, 1980)

Dr. Stephen J. Gage
Assistant Administrator for Research and Development
U.S. Environmental Protection Agency

To someone who is inclined to believe that the Federal Government spends its time searching for ways to make life difficult for the private sector, it would be easy to assume that we get a perverse delight out of instructing industry to burn more coal, while insisting at the same time that air quality be maintained. Such instructions sound almost like a Zen koan...one of those paradoxical word puzzles a Zen Master will use to confound his students and spur them toward enlightenment. "Without getting your robe wet, remove a stone from the bottom of the sea." "Without moving a muscle, stop the clanging of the bell across the river."

There's no getting around the fact that coal is a dirty fuel, contaminated with a variety of substances found to be harmful to human health and the environment. How on earth can we possibly triple the burning of coal by the year 2000, yet keep our air breathable?

We in EPA are aware of the dilemma industry faces. Far from sitting back with an inscrutable smile as you scramble to find solutions, we consider your problem our own. We are not in the business of assigning koans...that job will be left to the Zen Masters. But in the past decade, we <u>have</u> become enlightened about one thing: achievement of these twin goals <u>is</u> possible...at a reasonable cost...through the development of effective control technologies. Environmental degradation need not follow on the heels of a dramatic increase in coal use. The nation can have economic growth, achieve energy independence, and at the

same time maintain a high quality of life that so closely depends on the quality of our environment. Working together with industry, EPA has made and is continuing to make considerable progress in developing cost-effective ways of controlling coal's pollutants.

One success story has been sulfur oxide control, thanks to the development of flue gas desulfurization techniques. Although the first commercial use of FGD control systems took place in the early 1930's, the technology is only now becoming widely used, after ten years of extensive research, development and demonstration programs sponsored by EPA, the Tennessee Valley Authority, and the Electric Power Research Institute. As a result of these programs, FGD systems can now remove up to 90 percent of SO_2 emissions reliably and economically. Industry and utility companies, which in the early days of FGD development viewed the technology with a skeptical eye, are now adopting the process. At last count, 73 FGD units were in operation, with 127 units in design or under construction. Once all these units are operating, over a quarter of the current total U.S. coal-fired capacity will be equipped with FGD. Because of this growing acceptance of FGD, the total amount of sulfur oxides emitted to the atmosphere will remain constant or even decrease slightly from 1975 to 2000. This represents a tremendous victory for pollution control technology.

The history of particulates control is similarly cheering. Although the total amount of particulates generated between 1975 and 2000 is projected to double because of increased coal use, particulate emissions from coal combustion by electric utlities and industrial boilers will decline. This decline will be made possible by the widespread use of

modern, high-efficiency electrostatic precipitators. In the future, more advanced ESP's will likely attain the same level of performance at half the cost. And, while there is still work to be done in improving removal methods for fine particles and the difficult-to-remove ash typically produced from Western coals, the already established technologies of wet scrubbing and baghouses may provide the answers we're looking for. The bulk of the particulates problem has been licked.

What I mainly want to talk to you about today is a third air pollutant from coal combustion that may present us with our biggest air pollution challenge during the 1980's and beyond: nitrogen oxides. While sulfur oxide emissions are expected to decrease or remain constant between now and the year 2000, and while particulate emissions will decrease, nitrogen oxide emissions could easily double during this period...unless more effective control methods are developed. At present, about half the current NO_x emissions come from stationary sources, but by 1985, due to the trend toward greater combustion of coal, stationary sources may be responsible for 70 percent. Of the emissions from stationary sources, over half are contributed by utility and large industrial boilers alone. These large boilers emit an estimated 6 million tons of NO_x every year. Without controls, a single coal-fired boiler may spout 120 tons of NO_x into the atmosphere every day.

EPA is extremely concerned about the NO_x trends in this country. As a result, we have mobilized a significant portion of our research and development machinery toward combatting such emissions. In each of the last three years, through 1980, EPA has spent $12 million on developing methods of controlling NO_x pollution. In 1981 and 1982, funding will

continue at this high level, for a total expenditure of $60 million over the five-year period from 1978 to 1982. This level of funding should leave no doubt of EPA's dedication to the NO_x control effort.

Until recently, the effects of NO_x on humans and their environment has not been sufficiently appreciated. At last year's conference on EPA's Interagency Energy/Environment R&D Program, someone stood up and asked why EPA was devoting so much time and money to NO_x control. "NO_x makes your eyes burn," he said, "but sulfur oxides can kill you." Well, as a matter of fact, we now know that NO_x can do a great deal more than cause eye irritation. Long-term exposure to even low levels of NO_x can reduce resistance to respiratory infections such as bronchitis, pneumonia and influenza, and high-level, short-term exposure can have a variety of pronounced adverse health effects. The available evidence indicates that human health can be impaired by exposure to nitrogen dioxide concentrations approaching or falling within the range of recorded ambient air NO_2 levels.

Also of great concern are the environmental effects of NO_x once it has been transformed into other pollutants in the atmosphere. NO_x is a precursor of photochemical oxidants...the air pollutants most damaging to agriculture and forestry in the United States. Elevated concentrations of ozone, which is the chief ingredient of smog, have become a regional problem throughout the country, causing widespread damage to crops on both coasts. Oxidants have caused harm to agricultural crops, forest, and native vegetation in Southern California as well as widespread damage to crops in the East, and have become a new stress on ecosystems

in the Southwest.

Probably the most alarming environmental effect of NO_x is its role in the formation of acid rain, which is developing into what may be one of the most serious environmental threats of the century. As you heard, acid rain is formed when the gases of nitrogen and sulfur oxides combine with water vapor molecules in the atmosphere and are transformed into nitric and sulfuric acids. These acids are returned to earth by rain or snow or in dry form, sometimes hundreds or even thousands of miles from their sources, and can cause extensive ecological damage.

In New York's Adirondack Mountains, for example, acid rain has killed all of the fish in half of the high-altitude lakes. In Norway, the losses to salmon fisheries attributable to acid rain are estimated to be in the tens of millions of dollars. Acid rain may also be playing a part in the decline in forest growth observed in the Northeastern United States. In the eastern part of the U.S. and in Canada, there are extensive areas which are particularly susceptible to acidification because of the lack of natural buffering capacity in soils and water. In much of the West, the alkaline nature of the soils and lakes acts to neutralize acid rain, so the effects are not as pronounced there. But even in the West, ominous signs of vegetation damage have appeared.

NO_x accounts for 30 to 50 percent of the acid rain problem in the East, depending on the season. In the West, acid rain may be composed of up to 90 percent nitric acids formed from NO_x. Even as sulfur oxides are brought under control, the jump in NO_x emissions ensures that the acid rain threat will remain with us.

As required by the Clean Air Act, EPA has set a National Ambient Air Quality Standard for nitrogen dioxide, based on the level required

to protect the public health and welfare. This standard is currently pegged at 100 micrograms per cubic meter of air, or .05 parts per million, on an annual average basis. Several of our largest cities, including Los Angeles, Chicago, Denver, New York, and Salt Lake City, are currently exceeding this standard. In fact, many industiralized cities have short-term levels of nitrogen dioxide that reach several times the NAAQS.

EPA is ready and willing to work with you in attaining the ambient air and stationary source standards. A teamwork approach was successful when we were confronted with the need to reduce sulfur oxides and particulates. The same approach can work with NO_x control. I would also like to make a special point of welcoming our international friends to join us in this cooperative effort. As one who has appreciated the significant contributions made by the Jpaanese and, more recently, the Germans in advancing FGD technology, I am encouraged by the active participation of the highly capable engineers from Japan and West Germany as well as from Canada and the European Common Market.

The NO_x problem is, however, a tough nut to crack. It doesn't yield to the solutions that worked so well for sulfur oxide and particulates control. Physical coal cleaning, which can be used on some coal to reduce sulfur and ash content, has no effect on coal's nitrogen content, because the nitrogen is chemically bound to the coal. "Denitrogenation" -- that is, chemically removing nitrogen from coal -- is prohibitively expensive at present, and at any rate does not address the problem of thermal NO_x, which is formed by molecular reaction in superheated

combustion air. Flue gas treatment for NO_x control has been used with a fair amount of success in Japan on oil-fired boilers, but there are major financial and technical hurdles to applying that technology to coal-fired units. Even the coming age of synthetic liquid fuels made from coal, which may consume 120 million tons of coal in 1990 and 300 million tons in 2000, offers little hope for NO_x control -- in fact, the concentration of fuel nitrogen may be increased when coal is converted to a liquid.

However, the picture is not nearly as bleak as it may at first appear. There is an answer that is both cost-effective and energy-efficient. By modifying the conditions under which combustion takes place, an existing coal-fired power plant can reduce its NO_x emissions by 40 to 50 percent, which is generally enough of a reduction to meet current New Source Performance Standards for utility and large industrial boilers. When applied to new burner designs, combustion modification may reduce NO_x emissions by another two-thirds, yielding a total NO_x control of up to 85 percent. This means that NO_x emissions from coal burners can be reduced to the level found in oil burners. Yet, because combustion modification involves changes only in burner design, the cost is quite small -- less than one-half of one percent of the boiler cost. And, because we are ensuring that the new burners are as efficient as the older designs, the operating cost is nearly zero. Levels of other pollutants, such as particulates and hydrocarbons, are also reduced, because the total combustion process is optimized.

EPA's work in developing new low-NO_x burner designs is the centerpiece of its NO_x control effort. As early as 1971, EPA's Combustion

Research Branch at Research Triangle Park in North Carolina was experimenting with burners that produced a slower fuel-air mixing and a cooler flame than the traditional turbulent diffusion flame. We discovered that by suppressing flame temperatures and delaying the mixing of fuel and air, both thermal and fuel NO_x formation was hindered. Pilot scale work has proven that the technology is sound -- NO_x emissions were reduced to below 200 ppm.

The next step is to evaluate the low-NO_x burner's performance at as close to practical size as possible, in order to encourage industry acceptance of the technology. Two projects currently underway have this aim in mind; they will allow full-scale field evaluation of the low-NO_x burner.

One project will employ two industrial boilers in the range of 30 to 150 thermal megawatts, while the other will involve two utility boilers in the range of 100 to 300 megawatts. For each boiler, a prototype burner will first be constructed and then tested in an experimental facility. After the uncontrolled emissions of each host boiler has been measured, the low-NO_x burners will be installed and adjusted. Then, EPA will conduct a long-term evaluation of the burners, including environmental assessment and analysis of boiler operation. This will include corrosion testing, since slagging and fouling from coal ash is always a worry when burner design is altered. Finally, a guideline manual will be prepared to explain the technology.

The goal of these projects, which will be completed in late 1982, is not <u>only</u> to show that the new burners <u>do</u> indeed reduce NO_x emissions, but, that in doing so, they also equal or improve the thermal efficiency

of conventional boilers...that carbon emissions are not increased...and, that corrosion is prevented. One encouraging observation has been that increasing the scale of the low-NO_x burner toward practical size appears to make the technology more effective.

To aid EPA in the evaluation of these projects, and also to help keep the projects on the track toward commercialization, a technical review panel composed of representatives of boiler manufacturers, utilities, and research organizations will be on hand to offer advice and criticism. To provide a broader perspective on potential users, there will also be a technology transfer panel consisting of government agency representatives and trade association members.

The low-NO_x burner is being tested with a wide variety of U.S. coals. Initial tests indicate that it is effective even with high-nitrogen-content coals. Experiments with burning high-nitrogen residual fuel oils using low-NO_x technology provide both a worst-case scenario for conventional oils and a preview of what may be achievable with high-nitrogen coal and shale-derived oils. At pilot scale, the low-NO_x burner reduced NO_x emissions from these residual oils by 50 to 75 percent of what they would be if burned in a conventional boiler.

The results of all of EPA's tests with this new technology have met or exceeded program goals, so we feel comfortably optimistic about the kind of performance we will see when it is adopted commercially. In fact, we're very much encouraged by the results being obtained on a 700-mwe boiler in West Germany, an experiment which you will be hearing

about tomorrow morning.

What we've learned in applying combustion modification techniques and innovative burner designs to utility and large industrial boilers is also being applied to other combustion sources. These include small-scale industrial boilers, gas turbine engines, and residential oil furnaces. A new oil-fired furnace design we've been working on not only reduces NO_x by 65 percent, but reduces oil consumption an average of 15 percent. These are the kind of results we really enjoy seeing: increases in efficiency as well as improved pollution control.

A particularly exciting new control technology, which can be retrofitted to many existing coal-fired boilers with only minor modifications and which reduces sulfur oxide emissions as well as NO_x, is the limestone injection/multi-stage burner, or LIMB for short. The LIMB technology may be able to remove 50 to 70 percent of sulfur oxides at the same time that it reduces NO_x by 50 to 80 percent. And it can accomplish this at a cost for SO_2 control equipment of only $30 to $40 per kilowatt, as opposed to the average of $150 per kilowatt that wet scrubbing requires. Although the LIMB has only reached the bench/pilot scale stage of development here in the U.S., Germany is currently operating a 60 megawatt electric boiler using the technology, so we know that it works on a larger scale.

The idea of combining limestone injection for SO_2 control with a low-NO_x burner is not a new one. In 1967, UOP, building on earlier limestone injection experiments by Combustion Engineering, injected

limestone into an arch-fired burner, which is a naturally low-NO_x burner. SO_2 emissions were reduced by 50 percent at a stochiometric ratio of 1.3.

The 60 megawatt prototype limestone injection boiler in Germany, which I mentioned earlier, has been operating for one year. It fires West German lignite, and utilizes flue gas recirculation to minimize peak temperature and NO_x formation. At present, it is achieving 50 to 90 percent SO_2 removal at stochiometric ratios of 2.5 to 5.0. Retrofit capital costs for this technology are only $3.00 per kilowatt.

EPA has proposed a five-year research, development, and demonstration program that will bring the LIMB technology up to commercial scale. In the first year, EPA will characterize reactions and furnace conditions; evaluate impacts on furnace operation; and test the technology with a wide range of coal types and calcium-based sorbents. Next will come a year of field evaluation, in which EPA goals will be to demonstrate sulfur removal efficiency, optimize performance variables, determine if there are any adverse boiler side effects such as slagging, plugging and corrosion, and obtain design and cost data. Both wall-fired and tangentially-fired units will undergo testing. Another year will be spent installing the LIMB technology on full-sized boilers, which will then be subjected to two years of performance optimization and long-term evaluation. The total tab for the LIMB program will amount to $16.5 million, which will be a bargain if LIMB fulfills its initial promise. The development effort will be co-sponsored by EPA and the Department of Energy.

I've been talking a lot about EPA's plans for developing NO_x control methods, and the sort of projects we have underway. But, I'm

not forgetting the crucial role industry must play in this mission. EPA has the resources to provide the fundamental research and the testing of new control technologies, but we must rely on industry to provide the host sites that allow technologies to be tested under real-life conditions. And, we must depend heavily upon the commercial expertise and engineering experience of boiler manufacturers if a technology is to progress beyond the demonstration stage.

There's always an element of risk for the private sector when it invests in new equipment and new technologies. Control processes that look promising on the drawing board or during small-scale experiments don't always pan out when they are put into practical use. But we at EPA believe that with the kind of cooperation between government and industry we have enjoyed up to now, and with an equitable sharing of the risk which is, after all, inherent in all innovation, we can solve the pollution control challenges that we face.

For the rest of today and in the course of the next two days, you will be hearing about a lot of new ideas, new techniques, and new technologies aimed at keeping nitrogen oxides out of the air. Personally, I am very excited about these developments. A number of them will have far-reaching effects. For example, the low-NO_x burner or the LIMB technology may provide the technical fix for what will be an increasingly difficult political problem we will be having with our Canadian neighbors over our acid rain export to Southern Canada. Already these control methods have advanced from being just a gleam in an engineer's eye to successful operation in the laboratory, in pilot plants, and in a few

small combustors. I'm willing to bet you that when we gather together ain in a year, many of these technologies will be starting to move into the commercial market, working to produce electricity, generate power, and heat homes. And we'll all be able to breathe a little easier.

AIR QUALITY CONTROL FROM A STATE REGULATOR'S VIEWPOINT
(Luncheon Address, October 8, 1980)

L. Michael Henry, Chairman
Colorado Air Quality Control Commission

Ladies and Gentlemen, I am very honored to be here, but I must say that I am also considerably intimidated - for two reasons.

First, as I believe you know, I am substituting as a speaker for United States Senator Gary Hart from Colorado. I am intimidated because I certainly have nowhere near the knowledge and stature of Senator Hart on air quality issues.

We are very proud in Colorado that Senator Hart is respected so much in the national government to be the Chairman of the National Commission on Air Quality. He has also played a vital role in fighting to reinstate high altitude standards for automobile emissions. As you know, our mile-high altitude in Denver and much higher altitudes in our mountain communities contribute very significantly to automotive air pollution due to incomplete gasoline combustion at higher altitudes. In addition, Senator Hart has helped focus national attention on Colorado's deep concern about the prospect of economic and environmental problems resulting from projected massive development of the oil shale industry in the Piceance basin in northwestern Colorado. Senator Hart held a large public hearing in western Colorado on the oil shale development proposals of Exxon about five weeks ago. For some reason our Colorado Air Quality Control Commission was not notified of that meeting and, being a feisty Commission, we did send Senator Hart a message of complaint about this failure of communication. I cannot quite put out of my mind the possibility that Senator Hart was trying to punish me for this complaint by suggesting that I be thrust as a speaker before such an august meeting of international experts in stationary source control. Seriously, I do appreciate his suggestion that I might have some words of interest to you.

Secondly, I am very intimidated to be addressing you as a complete scientific lay person and amateur. I was very lucky to complete one course in high school physics and one course in high school chemistry. I have retained very little of those courses except for a deep respect for the discipline of those hard sciences. I am even less knowledgable in the laws of medical science or mechanical engineering or computer sciences, and I hope you will keep this in mind in any questions you might have.

Much of what I would like to talk to you about relates to the relationship between a citizen non-scientific regulatory commission as we have in Colorado and the regulated industries and the affected public.

In Colorado we have a 9-person part-time Air Quality Control Commission all appointed by the Governor. We are paid the grand sum of $40 a day for each day of work with a ceiling of $1,284 per year. We have regular meetings twice a month and numerous committee meetings with groups such as yours every month. Our Colorado statute requires the Governor to give consideration to appointing persons with appropriate scientific, technical, industrial, labor, agricultural, and legal training or experience, although no specific number of members needs to be from any specific background. The current members of our Commission include one lawyer, one lawyer=businessman, one woman rancher, one woman Chamber of Commerce representative and former City Council woman, two civically-active League of Women Voter members, one medical doctor, one professor of Engineering, and one engineer with a large manufacturing company.

Our current political makeup, which never is reflected in any of our votes, is three Democrats, three Republicans, and three unaffiliated members.

Our statutory obligations include the functions of preparing a comprehensive State Implementation Plan (SIP) to assure attainment and maintenance of the National Ambient Air Quality Standards, preventing significant deterioration and the preparing of emission control regulations.

We are very proud that the State Implementation Plan (required by the Federal Clean Air Act) which was submitted by Colorado to the Environmental Protection Agency in early 1979 was the first plan submitted by any state. We are not quite so proud that our State Implementation Plan was the first also to bring sanctions from the Environmental Protection Agency due to the failure of our Legislature to pass in a timely fashion legislation for inspection and maintenance of automobiles in our non-attainment areas. These Environmental Protection Agency sanctions have since been lifted after the Legislature did finally pass such Inspection and Maintenance legislation.

In the two and one-half years since I have been a member of the Colorado Commission, I have been extremely impressed with the quality and diligence and good common sense of the members of our Commission. Many have suggested that the State would be better served by having full-time paid members of the Regulatory Commission who would either be scientists or at least persons who can afford time to be scientifically and rigorously trained on the job. I certainly do wonder sometimes myself whether a deeper scientific training would have helped me be a better policy maker, particularly in the middle of public hearings when acronyms and medical phrases and chemical formulas and computer modeling results and engineering terms are thrown at us with scarcely any interconnecting English sentences.

On reflection, however, I believe that we do have a very workable system of regulatory air quality control in Colorado for four reasons:

First, we do have very competent technical permanent staff for the analyses of permit applications, for air monitoring, for planning and analysis of overall state strategies and for inspection and enforcement of our regulations. The trouble is that we do not have enough staff or enough funding to retain competent staff, partly due to a seven percent annual increase in State spending limitation which has been passed by our Legislature. The entire State Air Pollution Control Division has approximately seventy full-time staff, some of whom provide administrative support for the technical personnel. We have a budget of approximately 2.6 million dollars of which 10% is passed through to local health departments.

In addition to Colorado's spending limitations in a time of double-digit inflation we are also very concerned about future uncertainties in Federal Environmental Protection Agency budgeting in the next several years. We are very pleased however, with the staff resources which we have, given the limited staff numbers and the fiscal limitations we must live with.

Second, we have an enormous reservoir of public concern in Colorado about air quality control to spur us on. Very many people first came to Colorado around the turn of the last century on doctors' orders so that our pure air would ease the problems of people with tuberculosis and other respiratory diseases before they died. The fact is that many survived for very many years in our clean air. We have had a population boom for the last many years with many tourists and military short-term visitors attracted by our great weather and scenery and air to remain permanently in Colorado. None of these people are going to sit quietly by while our air deteriorates. Many times at our hearings, unfortunately my opinion, we hear very little from these people - as most of them have neither the scientific background nor the economic resources to spend time in testifying. However, we do feel a deep obligation to heed those who recall us to our heritage of clean air and

respect for our "purple mountains majesty" (as one public witness told us a couple of months ago). Many environmental groups do come however, and provide significant detailed analyses to us, which serves as a useful counter-balance to the great scientific resources of industrial representatives.

Third, we do have what I believe to be a very cooperative and mutually respectful attitude in Colorado between our Regulatory Commission and our major industries. All of our industries have a stake in maintaining Colorado as a healthy and attractive environment and all, with very few exceptions have recognized this obligation.

Fourth, we do have what I believe to be a very capable and constructive and common-sense Commission even given some of our technical weakness. We consult prior to drafting regulations with affected industry and with citizens and local governments and are very thoughtful about all of our final regulations. We are attempting now to develop a new approach to rule-making to respond to an EPA's regulation to protect visibility in Class I mountain parks areas which will come down in November. We have concluded that we would all be better served by a regulation which has been drafted jointly by the State and affected industry and the public at the beginning rather than having adversarial polarized groups at the public hearing yelling not only at each other, but at the Regulatory Commission. We are attempting to bring the resources of environmental groups and industries into the early stages in a calm atmosphere not only to defuse the process, but to capture the energy and resources and creativity of all groups, especially industry, when the resources of the State technical staff are limited, as I have said.

I think we all must recognize that when regulated industry has a role in finding solutions, certainly the outcome is much more practical and sensible. Those working deeply in an industry certainly know better than anyone else the unique problems of that industry. I am very favorable to the "bubble" concept, which is just now being applied to several industrial sources to allow the industry itself to find creative ways to reduce the overall emissions from that industrial site without outsiders attempting to establish regulations for every individual source inside the location.

I certainly commend the Environmental Protection Agency and the Electrical Power Research Institute for conducting this first joint symposium, which also reflects an understanding and need for cooperation between industry and regulators.

I will give you just a few comments on some of our specific Colorado problems:

At the time that our State Implementation Plan was submitted in early 1979, different parts of Colorado violated all of the National Ambient Air Quality

Standards except for sulfur dioxide. In Denver our 1977 average annual of NOx was .054 parts per million when the national standard is an annual average not to exceed .05 parts per million. In Denver during 1977, 37 percent of our nitrogen oxides (both NOx and NO_2) were from automobiles. Approximately 50% from large stationary sources; and approximately 10% from space heating. In 1982, our predictions are for approximately the same contributions toward our nitrogen oxide emissions, with a slight increase in the percentage to be emitted from space heating.

The fact that our nitrogen oxides are emitted by three different large factors differs from the situations we have with our other pollutants. In Denver, 93% of our carbon monoxide is contributed by automobiles, 85% of hydrocarbons are contributed by automobiles and 75% of our Total Suspended Particulates are contributed by automobiles. With the multiple contributors of nitrogen oxides, the control strategies are more complicated than if the greatest part of the pollutant came from one source.

In Colorado we are also facing a great deal of work and study to prepare regulations to protect our visibility in Class I areas. As I indicated, we in Colorado feel an enormous obligation to protect our mountain beauty. The task will be especially difficult due to the fact that visibility-measurement is not at all a fully-developed science.

Another very large problem facing us relates to the development of the oil shale industry in northwestern Colorado. We are extremely conscious that the entire nation is looking toward northwestern Colorado as a very valuable source of oil shale and also coal, but the scale of some of the proposed oil shale developments is absolutely overwhelming. Exxon, for example, has recently proposed an eight-million barrel per day development in the next several years. Most of our state officials and industry representatives believe that a 1.5 million barrel per day oil shale industry is much more realistic. Even so, the population increases and the energy capability to serve not only the industrial processes but the needs of the added people themselves, pose enormous problems for northwestern Colorado. In addition, the proposed MX missle system will also need approximately 180 megawatts of new power to serve not only the missile system itself, but the added population in western Colorado and eastern Utah.

One of our other major endeavors in Colorado relates to automobile inspection and maintenance. The Legislature finally did pass implementing Legislation in May of 1980. The program will be operational in full beginning in January of 1982. Many of us are concerned that our inspection and maintenance program will have little if any effect on reducing visible pollutants. Although most of us are most concerned about health-related pollutants, we believe that many members of the public are most keenly aware of the visible effects

which damage our mountain views. We will thus be feeling considerable public pressure to control the visible pollutants as aggressively as we do the invisible pollutants.

In other words, we have plenty of work to do in Colorado; and, given our history and our recent activites, I have every confidence that we will be able to handle our problems. With cooperation from industry, we will be able to do even better. I am very glad that you have offered me the opportunity to speak to you, and I trust that your visit to Colorado will be pleasant. Thank you very much.

REGULATORY PRESSURES FOR INCREASED NO_x CONTROL

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REGULATORY PRESSURES FOR INCREASED NO_x CONTROL

Electric utilities have had little concern with nitrogen oxide emissions. Particulates and sulfur oxides have received a great deal more attention. New and likely regulations will change this situation soon and could cost the electric utility industry as much as $11 billion (1).

I want to discuss the significance of impending and likely NO_x regulations upon the electric utility industry as well as the impact of other new laws upon the choice of an NO_x control technology.

The Clean Air Act Amendments of 1977 request a short-term ambient standard for NO_2. No standard has yet been set, but current discussion centers upon a one-hour average NO_2 ambient concentration of 0.125 - 0.50 ppm (2). Although this limit will be more restrictive than current SO_2 standards, small and medium-sized coal-fired power plants can probably satisfy the NO_2 limit (1). If we assume a one-hour standard of .25 ppm NO_2 and assume that all NO_x is converted to NO_2, then a 500 MW(e) power plant in flat terrain and complying with new source performance standards can easily conform to this standard if background levels of NO_2 are not already high. (See Table 1.) The same is also true for 1000 MW(e) plant. Significant background levels of NO_2 and uneven terrain would make it more difficult to satisfy the regulation.

Relaxation of the 100% NO_x to NO_2 conversion rate would make it easier to satisfy the regulation. A coal-fired power plant 1500 MW(e) or larger could not, however, meet a one-hour standard of .25 ppm even if it satisfied new source performance standards. Additional NO_x control would be needed.

A second requirement of the 1977 Clean Air Act Amendments is the Prevention of Significant Deterioration (PSD) provision for NO_2. The format for these regulations is not yet known, and several alternatives are under study. If, however, an increment format similar to that established for SO_2 and particulate matter is chosen, it will present significant constraints upon the electric utility industry. The allowable PSD increments for SO_2 and particulate matter are generally 25% of the ambient standards for Class II areas. For Class I areas the increments are about 2 - 5% of the ambient standards. If similar percentages were applied to the NO_2 standards, the impacts on power plant siting, size, and control technology choice could be great. For example, the NO_x emission from a 500 MW(e) coal-fired power plant satisfying new source performance standards would lead to concentrations which would exceed the increment by 50 percent. (1) We assume flat terrain and total conversion of NO_x to NO_2 in this calculation. Uneven terrain would lead to greater constraints, and relaxation of the total

conversion assumption would reduce the constraints a bit. The only way to satisfy the PSD regulations would be to construct very small coal-fired power plants with capacities less than about 300 MWe or to introduce controls which would reduce NO_x emissions beyond new source performance standards limits. The hypothesized Class I increments for NO_2 would require that 500 MWe power plants complying with new source performance standards be sited at least 100 km from Class I areas. Again smaller power plants or greater NO_x control could reduce the 100 km distance.

The Clean Air Act Amendments also provide for legislation to improve and minimize visibility impairment. Visibility regulations are imminent and could present significant constraints for power plants sited near Class I visibility areas. A relatively small amount of NO_2 in a power plant can lead to perceptible brownish coloration of the plume. In fact, preliminary results from the VISTA study undertaken jointly by EPA and several private groups, indicate that NO_2 is the most important contributor to plume coloration in the Southwest. (3) Visibility regulations will then certainly address NO_x emissions. According to one set of tentative criteria (4), a coal-fired power plant as small as 750 MWe may require flue gas treatment of NO_x if the

plant is sited in the visual range of the Class I visibility area. (1) The visual range is 100 to 200 km in the West; in the East it is from 15 to 50 km.(5)

There are two additional environmental concerns which could lead to increased pressures for decreased NOx emissions. The nitrogen oxides, along with hydrocarbons, are precursors to ozone formation. Oxidant control in the past has relied heavily upon hydrocarbon emissions control, but future controls may also require additional NO_x limitations. This is of particular concern in those 16% of U.S. counties which violate the oxidant standard (6). These counties, in general, are the sites of the major urban areas in the U.S. Power plants upwind of these areas might anticipate demands for increased NO_x control. In some places, such as California, demands have already been formulated.

The acid rain problem is receiving a lot of attention, and there is some public clamor to control acid rain. Because nitrogen oxides may be responsible for up to 30 - 40% of the acidity of rainfall in the Northeast U.S. (7), any efforts to control acid rain will probably involve some control of nitrogen oxide emissions from stationary sources.

All five of the planned and potential regulations can have tremendous impacts upon the electric utility industry, particularly in its planning of new plants. The regulations

will impact coal-burning power plants most, although synfuel plants can also be significantly impacted. At a time when nuclear power plants were more popular, the increased restrictions and costs imposed by these regulations could lead to a greater share for nuclear of new power plants. Given the current mood, this is unlikely to happen. Alternative coal types are not likely to influence NO_x emissions significantly, but shale oil and coal liquid could yield greater NO_x emissions than fuel oil. (1) Hence these regulations could influence fuel choice and the demand for shale oil and synthetic fuels. The regulations could lead to smaller power plants as they may be allowed with existing and inexpensive controls and they may be sited more easily. If, however, a PSD increment for NO_2 is set as outlined above, the maximum allowable power plant size, 300 MWe for a coal-fired plant, may be too small for utility consideration. Siting will also be impacted. New power plants can expect to be sited further from Class I areas and probably further from oxidant non-attainment areas.

Greater NO_x emissions control can allow power plants to satisfy the above regulations without decreasing size or siting flexibility. The potential PSD increments could, however, even pose problems for larger power plants using the most advanced available control technology.

The increased costs of the control technclogies will be weighed against size and siting in planning new power plants.

There is another factor, however. The most advanced control technologies are new and largely untested. Before these new technologies are chosen, we must make sure that they do not introduce any new risks to the environment and that they satisfy regulations in addition to those which they are designed to help meet. Table 2 gives a partial list of those regulations which require compliance of new technologies with some minimal level of risk; moreover, there are concerns with some of the substances which have been mentioned in connection with the NO_x control technologies. The Clean Air Act Amendments under section 112 (NESHAP), for example, are concerned with airborne carcinogens including polycyclic organic materials (POM). It is unclear whether or not combustion modification leads to increased POM emissions. The Clean Water Act Amendments are concerned with ammonia and nitrosamines along with many other toxics. It is unclear as to which if any quantities of these substances may be released to the environment with selective catalytic reduction. The Occupational Health and Safety Act is concerned with the risk of occupational exposure to vanadium, a catalyst in selective catalytic reduction.

The risks associated with this use of vanadium have not yet been estimated. The Hazardous Materials Transport Act is concerned with the risk of transporting ammonia as well as other substances. The risk of ammonia transport associated with selective catalytic reduction is unknown. Other legislative acts raise other concerns.

These examples illustrate the complexity of the current regulatory environment and the necessity to consider a much broader set of regulations than previously. This is particularly true for the NO_x control technologies. Relatively little experience is available at the operational level. As these technologies are tested for efficacy of NO_x control, they must also be examined to insure that they do not introduce any new risks to the environment and that they can comply with the entire regulatory spectrum. The failure to identify and correct any deficiencies during the development of the technologies can only lead to greater costs and problems. The uncertainty attached to any new technology must be weighed by utilities in deciding how to comply with the new NO_x regulations. There is a price attached to uncertainty. In this case one could imagine technologies which may be obsolete before they are constructed or the need to build one gismo on top of another à la Rube Goldberg. Practices for the use of the technologies may have to be altered as well. All of these will require more money, lots of it. The result may be that utilities will give

more weight to siting solutions and smaller power plants in the near term than they would have given in a simple regulatory environment.

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TABLE 1: Power Plant Abilities to Satisfy a 1-hour NO_2 Standard of 0.25 ppm

Standard of 0.25 ppm, Power-plant* abilities to satisfy standard with a 1-hour NO_2

Power Plant Size	Maximum Concentration as % of Standard
500 MW(e)	40%
1000 MW(e)	80%
1500 MW(e)	120%

* coal-fired power plant satisfying New Source Performance Standards located in flat terrain

TABLE 2: Partial List of Regulations Requiring Risk Assessment

- o Clean Air Act Amendments
  - NESHAP (National Emissions Standards for Hazardous Pollutants
- o Clean Water Act
- o Occupational Safety and Health Act
- o Hazardous Materials Transport Act
- o Resource Conservation and Recovery Act
- o Toxic Substances Control Act
- o Federal Railroad Safety Act
- o Ports/Waterways Safety Act
- o Safe Drinking Water Act

DEVELOPMENT AND REVISION OF AIR QUALITY STANDARDS WITH SPECIAL ATTENTION TO THE NO_2 STANDARD REVIEW

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ABSTRACT

This paper describes the process for review of National Ambient Air Quality Standards. Special attention is given to the issues facing the Environmental Protection Agency in assessing the need for and nature of possible modifications to the NO_2 ambient air quality standards. The legal requirements for the Clean Air Act Amendments of 1977 are discussed as they apply to this review and to the decision process in making a standard choice. The paper describes not only the importance of the scientific basis for selecting a standard but also the role of the policymaker and the judicial process. Criteria document development, the scientific review process, the preliminary staff position paper and the public review process are all described. Finally, the critical elements in the upcoming NO_2 standard decision are identified and discussed.

INTRODUCTION

The development of National Ambient Air Quality Standards (NAAQS) is a step-by-step process followed by the Environmental Protection Agency (EPA) that includes: (1) the assessment of scientific information, (2) generation of a consensus within the scientific community on the veracity of this assessment, (3) an exchange of views and information with the public sector following proposal of a standard, and (4) promulgation and enforcement of a final rule. EPA's charter for this review process is the Clean Air Act and related amendments passed by the United States Congress. This paper reviews the requirements of this legislation, how the Agency has implemented these requirements, and a brief status update of the NO_2 standard review.

BACKGROUND

Seven National Ambient Air Quality Standards have been established under the provision of the Clean Air Act Amendments. Substances for which these standards have been set are presented in Table 1 and include carbon monoxide (CO), hydrocarbons (HC), lead (Pb), nitrogen dioxides (NO_2), sulfur oxides (SO_x), particulate matter (TSP), and ozone (O_3). All of these standards with the exception of ozone and lead were originally set in 1971. The 0.12 ppm ozone standard is the result of the 1978-79 review and revised the old 0.08 ppm oxidant standard, while the lead standard was promulgated in October 1978 after litigation brought against the Agency by the Natural Resources Defense Council.

Following promulgation of the original standards, a number of reviews of the air quality criteria were conducted by the National Academy of Sciences (NAS). For example, the NAS reviewed the basis for all of the standards for Congress in 1974, and another NAS study was prepared on the criteria for sulfur oxides for the Senate Committee on Public Works in 1975. EPA also contracted with NAS to review the scientific basis for each of the criteria pollutants, resulting in NAS reports completed in 1977 and 1978.

The NAS reviews found that there was insufficient new scientific information to justify changing the existing standards, although in several instances revisions to ambient air quality criteria were recommended.

LEGISLATIVE REQUIREMENTS

The goal of the Clean Air Act is to protect the public health and welfare and enhance the quality of the nation's air. Under the Act, the Federal government is responsible for establishing, on a nationwide basis, ambient air quality standards that are stringent enough to protect the public health with an adequate margin of safety. In order to provide for attainment of these standards, the States are responsible for specifying emission limitations and other programs for individual sources through State implementation plans (SIP's).

The first step in establishing an ambient air quality standard is a finding by the Administrator of the Environmental Protection Agency that a particular pollutant causes or contributes to air pollution which, in the words of the Act, "may reasonably be anticipated to endanger the public health or welfare." Within 12 months after the listing of a pollutant under section 108(a) of the Clean Air Act, the Administrator must publish an air quality criteria document which will form the scientific basis for the ambient air quality standard. The criteria document must contain the "latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare."

Simultaneously with publication of the criteria document, the Administrator must propose primary and secondary national ambient air quality standards, as appropriate. A primary standard is one that, in the Administrator's judgment, is required to protect the public health with an adequate margin of safety. Costs of attainment are not a germane consideration in setting the primary standard, although such costs are to be considered in the development of SIP's. A secondary standard is one that adequately protects the public welfare. Public welfare is defined as including, but not limited to, effects on soils, water, crops, vegetation, man-made materials, animals, wildlife,weather, visibility, climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being. After providing a public

comment period and hearing, the Administrator is required to promulgate final standards; standards are usually promulgated within 6 months of his initial proposal.

The 1977 amendments require that all existing criteria documents be reviewed at 5-year intervals by a newly created Clean Air Scientific Advisory Committee (CASAC) of EPA's Science Advisory Board (SAB). An independent body made up of scientists and engineers with substantial scientific and technical expertise, the SAB is chartered by the Administrator to provide critical review of scientific matters before the Agency, as well as independent advice. (The SAB's authority to comment on draft criteria documents was statutorily established by the Environmental Research Development and Demonstration Authorization Act of 1978.) In addition to the establishment of the CASAC, section 109(d) of the 1977 Act further directed the Administrator to complete reviews of all existing standards and criteria before the end of 1980 and at no longer than 5-year intervals thereafter, and to revise the criteria and standards, as appropriate, based on those reviews.

Once an ambient standard is promulgated, responsibility under the Clean Air Act shifts from the Federal government to the States. Within 9 months after promulgation, each State is required to prepare and submit a State implementation plan (SIP) to EPA for approval. These SIP's must contain emission limitations and must describe all other measures necessary to attain the primary standard "as expeditiously as practicable" but not later than 3 years after EPA approval and to attain the secondary standard within a reasonable time.

CONSIDERATIONS IN ESTABLISHING AIR QUALITY STANDARDS

When the Agency undertakes either to establish or revise a standard, questions often arise concerning what the Administrator must consider in establishing a primary standard. Section 109(d) of the Clean Air Act requires that national primary ambient air quality standards be set at a level allowing for an adequate margin of safety, which the Administrator judges is adequate to protect the public health. The statute and legislative history[2] make it very clear that the standards are to be solely health based, designed

to protect the most sensitive group of citizens (but not necessarily the most sensitive members of that group) against adverse health effects. The task of deciding which health effects are adverse is a difficult one, and to accomplish it the Administrator must exercise his judgment as allowed by the Act in the investigation of the range of health effects of a pollutant and in the consideration of the risks disclosed by the investigation. In addition, the requirement of a margin of safety and the precautionary nature of the Act indicate that the standards must protect against uncertain, as well as certain, effects.

In the process of setting the primary standards, the Administrator must typically deal with two different kinds of issues: (1) which effects on a continuum of known effects should be regarded as adverse? and (2) what degree of additional protection is required to protect against uncertain harms--those not yet identified by research, or identified but not yet fully understood?

Any attempt to determine that level of pollutant exposure at which the effects are adverse to the sensitive population faces an immediate problem: investigation of the effects typically reveals that while there are levels above which "adverse effects" clearly exist, it is not generally possible to identify sharp "thresholds" for such effects. Rather, expanding scientific knowledge and better analytical techniques have made it clear that pollutant effects typically exist as a continuum, ranging from clearly serious health effects at high pollutant concentrations, to physiologically detectable effects of uncertain significance, to effects which are too subtle to measure.

Even though Congress was aware that there is no sharp "breakpoint" between a "no-effect" level and a level where the effect is clearly adverse, it still required that standards be set and that the standards be set at the point where there is no adverse effect for the sensitive population. The fact that health effects exist on a continuum creates a difficulty in identifying that level. In addition, the term "adverse" itself is difficult to define in the abstract. At different points in the continuum are levels of pollutants at which the effects will be conceded to be "adverse" by any given person. That point will vary, however, since medical judgments about what is "adverse" will vary with the information available to the

person and his or her viewpoint. In a given case, determination of what health effects are adverse may be as much an exercise of informed judgment as a factual injury.

In recognition of this, Congress in section 109(b)(1) of the Clean Air Act explicitly provided that the Administrator is to exercise his judgment in setting the standard. Though relying heavily on scientific advisors for technical evaluation of data and for those judgments that are essentially scientific in nature, the Administrator alone is responsible for considering risks and determining at what pollutant concentration the health effects on the sensitive population should be regarded as adverse. Medical experts may differ as to which particular health effects are adverse, but the statute gives the Administrator the responsibility of making that judgment.

RECENT SUPPORT FOR EPA'S APPROACH TO STANDARD SETTING

On the 27th of June 1980, the United States Court of Appeals, upheld the principal elements of EPA's standard-setting philosophy in its decision on the lead standard.[3] The court specifically supported EPA's contention that: (1) costs cannot be considered in selecting primary or secondary standards and, (2) the Administrator's authority and responsibility for making reasoned judgments in protecting public health in the face of incomplete or uncertain evidence. Two cites from the court decision amply verify this judgment.

Statutory Authority

"Furthermore, we agree with the Administrator that requiring EPA to wait until it can conclusively demonstrate that a particular effect is adverse to health before it acts is inconsistent with both the Act's precautionary and preventive orientation and the nature of the Administrator's statutory responsibilities. Congress provided that the Administrator is to use his judgment in setting air quality standards precisely to permit him to act in the face of uncertainty. As we read the statutory provisions and the legislative history, Congress directed the Administrator to err on the side of caution in making the necessary decisions. We see no reason why this court should put a gloss on Congress' scheme by requiring

the Administrator to show that there is a medical consensus that the effects on which the lead standards were based are 'clearly harmful to health'. All that is required by the statutory scheme is evidence in the record which substantiates his conclusions about the health effects on which the standards were based. Accordingly, we reject the Lead Industry Association's (LIA) claim that the Administrator exceeded his statutory authority and turn to LIA's challenge to the evidentiary basis for the Administrator's decisions."

Cost and Economics Role in Standard Setting

"The petitioners' first claim is that the Administrator exceeded his authority under the statute by promulgating a primary air quality standard for lead which is more stringent than is necessary to protect the public health because it is designed to protect the public against 'subclinical' effects which are not harmful to health. According to petitioners, Congress only authorized the Administrator to set primary air quality standards that are aimed at protecting the public against health effects which are known to be clearly harmful. They argue that Congress so limited the Administrator's authority because it was concerned that excessively stringent air quality standards could cause massive economic dislocation.

In developing this argument, St. Joe contends that EPA erred by refusing to consider the issues of economic and technological feasibility in setting the air quality standards for lead. St. Joe's claim that the Administrator should have considered these issues is based on the statutory provision directing him to allow an 'adequate margin of safety' in setting primary air quality standards. In St. Joe's view, the Administrator must consider the economic impact of the proposed standard on industry and the technological feasibility of compliance by emission sources in determining the appropriate allowance for a margin of safety. St. Joe argues that the Administrator abused his discretion by refusing to consider these factors in determining the appropriate margin of safety for the lead standards, and maintains that the lead air quality standards will have a disastrous economic impact on industrial sources of lead emissions.

This argument is totally without merit. St. Joe is unable to point to anything in either the language of the Act or its legislative history that offers any support for its claim that Congress, by specifying that

the Administrator is to allow an 'adequate margin of safety' in setting primary air quality standards, thereby required the Administrator to consider economic or technological feasibility. To the contrary, the statute and its legislative history make clear that economic considerations play no part in the promulgation of ambient air quality standards under Section 109."

This court decision would appear to lay to rest arguments questioning the role of economics in standard setting and the Administrator's responsibility in making choices under uncertainty.

STANDARD DEVELOPMENT PROCESS

Criteria Document

Figure I illustrates the various steps in the standard development process. The first step in the process is to review criteria, and develop a revised criteria document where appropriate. Main responsibility for production of the document rests with the Environmental Criteria and Assessment Office (ECAO/RTP) in EPA's Office of Research and Development (ORD). The first phase of the documentation process is to plan and initiate document preparation procedures. This phase includes assembling an internal EPA task force and recruiting outside experts as consultants to aid in writing the document. Together, these groups develop a work plan and define a schedule for production of the document.

The next step includes accumulating and analyzing literature and writing initial rough drafts of document chapters. Hard copies of every article cited are obtained and kept on file for public inspection at ECAO facilities. The actual writing of the drafts is carried out by ECAO staff, other EPA research scientists, or non-Agency consultants, depending upon the avialability of authors with the required expertise. These activities result in the production of an initial working draft of the document.

Following this phase, a workshop is held, where non-Agency experts meet with the document preparation team, which includes authors of the draft chapters, to provide preliminary peer review of the document contents and to assist in its revision. Post-workshop revisions lead to the production of a first external review draft of the document. This draft is circulated to

the public and CASAC for review and comment. The document is reviewed by CASAC at a public meeting.

Following the public review meeting, ECAO staff members undertake indepth cataloging of public and CASAC comments on the first external review draft. All comments from CASAC, the public, and other reviewers are passed on to the appropriate authors and are given consideration in revising the document. Each comment and its disposition is considered and entered into a docket, which is available for public inspection. Consideration of comments and appropriate revision of the document text result in a second external review draft.

The revised and reprinted draft is normally submitted to the public and the CASAC again for external review, and an effort is made to achieve final closure on the document with the CASAC. If no substantive critcisms are received as a result of this cycle of review or remain outstanding after this cycle, then the CASAC/SAB indicates, in a written report to the Administrator, that such is the case, confirming the CASAC's evaluation of the document as being of appropriate quality for use as the scientific basis for the related air standard.

STAFF PAPER

Once the criteria document has been reviewed by the public and the CASAC and the document is nearing its final form, the Agency staff prepares a paper, which evaluates the key studies in the criteria document and identifies critical elements to be considered in the review of the standard. The staff paper identifies those studies that the staff believes should be used in making the best scientific judgment on the level at which adverse effects signal a danger to public health in the sensitive population. In addition, the paper provides a discussion of the uncertainties in the medical evidence and of other factors that the staff believes should be considered in selecting an adequate margin of safety and a final standard level. In addition, the paper evaluates studies that the staff believes should be used in making the necessary scientific judgments on the level at which adverse effects signal a danger to public welfare. The paper <u>does not</u> present a judgment on what concentration level should be established for

the standard. The paper does help bridge the gap between the science contained in the criteria documents and the judgment required of the Administrator in setting ambient standards.

The staff paper is reviewed externally by the public and the CASAC. A public meeting is held with the CASAC to receive their comments and the comments of the public. Once the paper has been reviewed by the CASAC, the scientific judgments made in the paper form the basis for the staff's recommendation to the Administrator on any revisions to the standard. Our initial experience with the review of the CO staff paper[4] was extremely good. The CASAC members were very positive in their comments, and they found the paper to be an excellent vehicle for conveying the staff's view of how studies presented in the criteria document should be used in setting standards.

Assessing and interpreting the scientific evidence is a very complex undertaking. For example, the CO criteria document contained over 200 references on the human health effects of CO. Reviewing these studies, determining which are the most relevant to standard setting, and finally interpreting the scientific evidence from the relevant studies are very difficult and challenging tasks which the Agency must undertake each time a standard is reviewed. This is even more difficult because there is often considerable disagreement in the scientific community over how the studies should be interpreted. The preparation of the staff paper and its review by the public and the scientific community are our way of ensuring that the staff's interpretation of the scientific evidence is sound and that the Administrator has available to him a properly interpreted data base for his decision making on air standards.

REGULATION DEVELOPMENT

The first general principle of the regulation development process is the extensive and continuous participation by various EPA offices. Participatory decision making continues to be important at EPA because systematic review by offices other than the office with primary responsibility provides several types of valuable input. Scientists and engineers check data and analyses; lawyers check procedures, clarity, and consistency with the law; and other

program managers evaluate how proposed regulations would affect their programs. This process starts when the lead office, which has the responsibility for the standard, invites Assistant Administrators, the General Counsel, Regional Offices, and Staff Offices to send representatives to participate in a work group in developing a regulation.

The work group advises and assists the lead office in preparing a proposed regulation. The initial review of the regulation is by the Steering Committee. This committee is a continuing group representing the six Assistant Administrators' staff. Following Steering Committee reviews, proposed regulations are reviewed by all Assistant Administrators, General Counsel, and chief Staff Office directors. When consensus is not reached at a particular level, the disagreement is spelled out, and the matter is taken to a higher level for review. When consensus is reached on major issues at lower management levels, the lead office identifies for senior management the nature of the issue and the consensus that has been reached. As a result, final decisions remain with publicly responsible appointed officials at the top of the Agency.

The Agency also places a high priority on public participation in our standard review process. EPA has provided for public and scientific review of our criteria documents and staff papers. Ample public review is provided for during rulemaking under section 307(d) of the Clean Air Act, as added by the 1977 Amendments, including establishment of a public docket, provision for a public hearing, and an opportunity to submit written comments. The final regulation includes the Agency's response to the public comments.

The Agency process has worked extremely well in practice and was used as the model for regulatory reform as presented in Executive Order 12044. The process ensures both outside public review and top Agency management review during the standard development process. The result has been an open and objective decision-making process that gives consideration to opposings viewpoints.

NO_2 STANDARD REVIEW

At this stage of the NO_2 standard review process, EPA has completed a draft criteria document that covers concerns for both a short and a long-term air quality standard. The document is currently undergoing review by the CASAC and is expected to receive a favorable endorsement from that group. A meeting will be held with the CASAC group to discuss not only the veracity of the criteria document but also EPA's preliminary ideas on how the scientific evidence will be used in making a decision on NO_2 standards.

To provide insight into how this process may progress, Tables 2 and 3 are included as a representation of the critical studies expected to play a major role in selecting the standard. As can be seen from Table 2, clinical studies report a variety of effects at concentrations ranging from 0.1 ppm to 2.5 ppm. These effects include subtle responses such as elevated reaction to a bronchial constrictor agent at 0.1 ppm to significant and measurable pulmonary function decrements in the range 0.7 to 2.0 ppm. Other responses such as symptomatic effects and slight pulmonary function impairment have been observed at intermediate concentrations. A decision which has yet to be made by EPA, is just what level of response and associated concentration, should be considered as an indicator of an adverse health effect. EPA is soliciting counsel on this issue from the CASAC and from the public and other interested parties.

A second series of studies which will bear on the standard decision are the so-called "gas stove studies." These studies seem to indicate that young children suffer an elevation in the frequency of respiratory illness at NO_2 concentrations of about 0.4 to 0.6 ppm. Unfortunately, a key piece of information is missing from the gas stove studies, in that the exact air quality distributions are unknown. It is not clear whether the 0.4 - 0.6 peak concentrations are for very short (minutes) periods of time, or for longer periods (hours). It is also uncertain whether the observed response is due to a single peak concentration, to several peak concentrations, or to the long-term chronic exposure over a several-month period. Some evidence does

exist, however, from animal studies, that it is the repeated short-term peak concentrations that are most responsible for the reported insult.

A third area of major concern are the animal studies reporting a decreased resistance to disease at NO_2 concentrations of 0.5 ppm and above. These studies are, in turn, supported by other animal work showing less pronounced effects at considerably lower concentrations. These effects, such as destruction of lung tissue are considered by some investigators, precursors to the elevated disease levels shown at higher concentrations. Just how EPA will use these studies in arriving at a final standard decision, will not be decided until after discussions with the CASAC and after there has been an opportunity to receive public input on this important issue.

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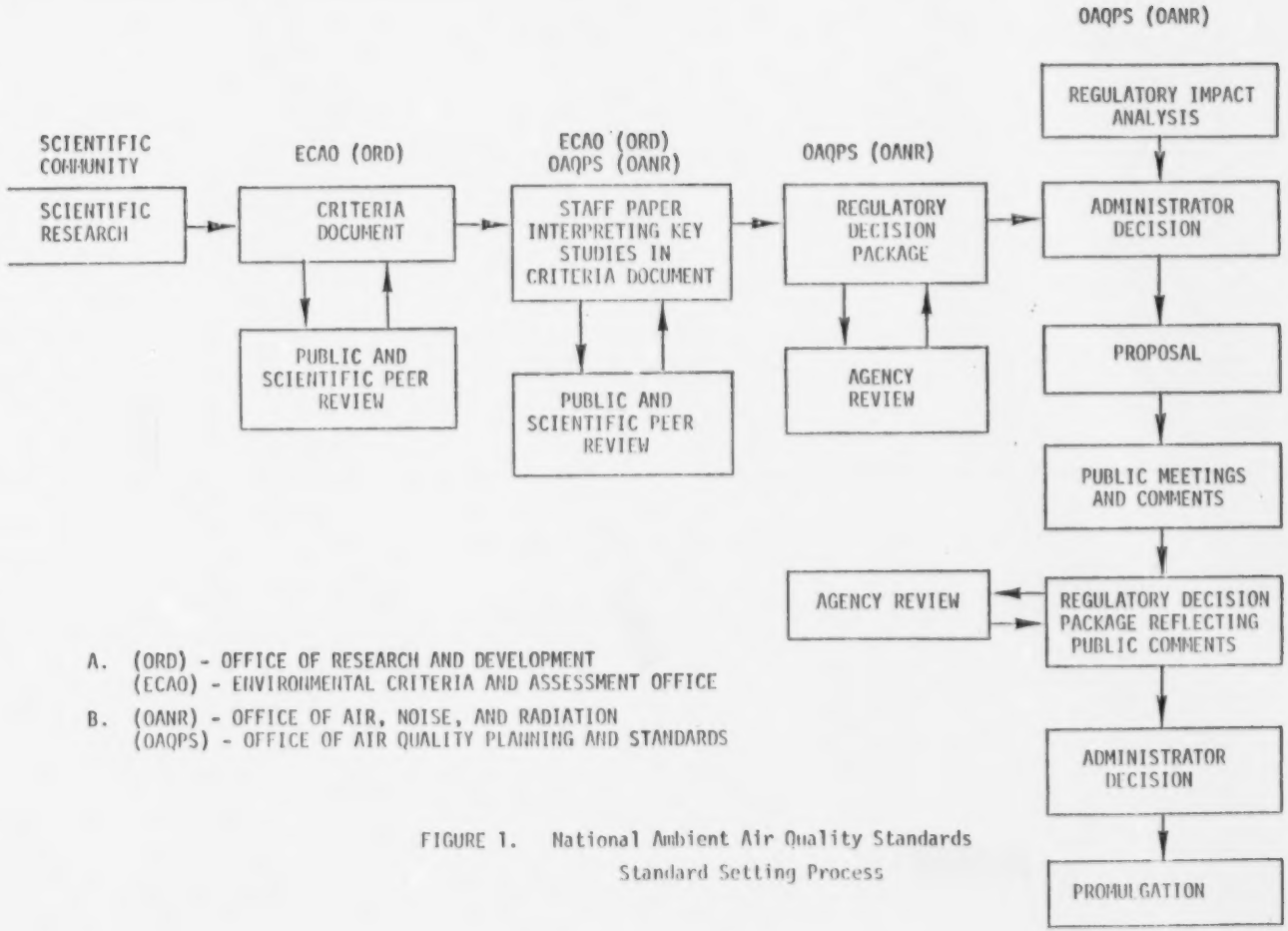

A. (ORD) - OFFICE OF RESEARCH AND DEVELOPMENT
(ECAO) - ENVIRONMENTAL CRITERIA AND ASSESSMENT OFFICE

B. (OANR) - OFFICE OF AIR, NOISE, AND RADIATION
(OAQPS) - OFFICE OF AIR QUALITY PLANNING AND STANDARDS

FIGURE 1. National Ambient Air Quality Standards
Standard Setting Process

TABLE 1. NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Primary Standards	Averaging Time	Secondary Standards
Carbon monoxide	10 g/m^3 40 g/m^3	8-hour[a] 1-hour[a]	Same as primary
Hydrocarbons (Non-methane)	160 $\mu g/m^3$	3-hour[a] (6 to 9 a.m.)	Same as primary
Lead	1.5 $\mu g/m^3$	Quarterly average	Same as primary
Nitrogen oxides	100 $\mu g/m^3$	Annual (arithmetic mean)	Same as primary
Particulate Matter (TSP)	75 $\mu g/m^3$ 260 $\mu g/m^3$	Annual (geometric mean) 24-hour[a]	60 $\mu g/m^3$ [b] 150 $\mu g/m^3$
Ozone	235 $\mu g/m^3$	1-hour[c]	Same as primary
Sulfur oxides	80 $\mu g/m^3$ 365 $\mu g/m^3$ ---	Annual (arithmetic mean) 24-hour[a] 3-hour[a]	--- --- 1300 $\mu g/m^3$

[a]Not to be exceeded more than once per year.

[b]Guide to achieving the 24-hour standard.

[c]The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 235 $\mu g/m^3$ is equal to or less than 1.

TABLE II. KEY STUDIES

Compilation of Effects Reported in Selected Human Studies Examining Nitrogen Dioxide Exposures

NO_2 Concentration, ppm	Exposure Durations	Study Population	Reported Effect(s)*	References
0.1	1 hr.	20 asthmatics	Effect of bronchoconstriction enhanced after exposure to NO_2 in 13 of 20 subjects. Neither effect observed in 7 of 20 subjects. A bronchoconstrictor (carbachol) was used.	Orehek, 1976
0.5	2 hrs.	10 healthy adults 7 chronic bronchitics 13 asthmatics	1 healthy and 1 bronchitic subject reported slight nasal discharge. 7 asthmatics reported mild symptomatic effects. Bronchitics and asthmatics showed no statistically significant changes for all pulmonary functions tested when analyzed as separate groups, however small, but statistically significant changes in quasistatic compliance were found when analyzed as a single group.	Kerr, et al., 1979
0.5 to 5.0	approx. 15 min.	63 chronic bronchitics	Significant increase in airway resistance at or above 1.6 ppm	Von Nieding et al. 1971
0.6	2 hrs.	15 healthy exercising adults	No physiologically significant changes in cardiovascular, metabolic, or pulmonary function after 15, 30, or 60 minutes of exercise.	Folinsbee et al., 1978
0.7 to 2.0	10 mins.	10 healthy adults	Increased inspiratory and expiratory flow resistance of approximately 50% and 10% of control values measured 10 mins. after exposure.	Suzuki and Ishikawa, 1965
1.0	2 hrs.	16 healthy adults	No statistically significant changes in pulmonary function tests with exception of small changes in forced vital capacity (1.5% mean decrease; $p < .05$). Respiratory symptoms slightly increased after exposure to NO_2, but change not statistically significant compared to controls.	Hackney, 1978
1.0 and 2.5	2 hrs.	8 healthy adults	Increase in airway resistance at 2.5 ppm but not at 1.0 ppm	Beil and Ulmer, 1976
1.0 to 2.0	2½ hrs.	10 healthy adults	Alternating exercise and rest produced significant decrease for hemoglobin, hematocrit, and erythrocyte acetycholinesterase.	Posin, et al., 1978

TABLE III. COMPILATION OF REPORTED EFFECTS ASSOCIATED WITH EXPOSURE TO NITROGEN DIOXIDE IN THE HOME IN COMMUNITY STUDIES INVOLVING GAS STOVES

Concentration[a] (ppm)	Study Population	Reported Effects	Reference(s)
Frequent peaks 0.4-0.6 (gas), maximum peak 1.0 (gas), 95th percentile 24 hr avg in activity room 0.02-0.06 (gas) 0.01-0.05 (elec)	8,120 children, ages 6-10, 6 different cities, data also collected on history of illness before age 2	Significant association between history of serious respiratory illness before age 2 and use of gas stoves. Small but statistically significant decreases in pulmonary function (FEV_1 and FVC) in children from gas stove homes.	Speizer et al., 1980
NO_2 not measured at time of study	2,554 children from homes using gas to cook compared to 3,204 children from homes using electricity, ages 6-11	Bronchitis, day or night cough, morning cough, cold going to chest, wheeze, and asthma increased in homes with gas stoves	Melia, et al., 1977
NO_2 not measured in same homes studied	4,827 children, ages 5-10	Higher incidence of respiratory symptoms and disease associated with gas stoves	Melia, et al., 1979
Kitchens: .005-0.317 (gas) .006-0.188 (elec) Bedrooms: 0.004-0.169 (gas) 0.003-0.037 (elec)	808, ages 6-7	Higher incidence of respiratory illness in gas-stove homes	Florey, et al. 1979 Companion papers to Melia et al., 1979; Goldstein et al., 1979
Sample of Households 24 hr avg 0.005-0.11 (gas) 0-0.06 (elec) 0.015-0.05 (outdoors)	128 children, ages 0-5 346 children, ages 6-10 421 children, ages 11-15	No significant difference in reported respiratory illness between homes with gas and electric stoves in children from birth to 12 years old	Mitchell et al., 1974 See also Keller et al., 1979
Peak hourly 0.25-0.50 (gas), max hr 1.0 (gas)	Housewives cooking with gas stoves compared to those cooking with electric stoves.	No increase in respiratory illness	U.S. EPA, 1976
24 hr avg 0.005-0.11 (gas) 0-0.06 (elec) 0.015-0.05 (outdoors)	Housewives cooking with gas stoves, compared to those cooking with electric stoves. 146 households	No evidence that cooking with gas is associated with increase in respiratory disease	Keller, et al. 1979
See above for monitoring data	Members of 441 households	No significant difference in reported respiratory illness among adults in gas vs electric cooking homes	Mitchell, et al., 1974 See also Keller et al., 1979

[a]Exposures in gas stove homes were to NO_2 plus other gas combustion products.

A C I D R A I N I S S U E S

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ABSTRACT

The U.S. Environmental Protection Agency (EPA) is concerned about the effects of acid rain because the acidity of precipitation falling on the U.S., Canada, and Scandinavia has been increasing for the past two decades. An annual average precipitation of pH of 4.0 to 4.5 is not uncommon in the eastern U.S., southeastern Canada, and western Europe.

Acid rain also has become more widespread in the past twenty years. Once confined to urban and industrial areas, the effects of acid rain are now being experienced in places as remote from industry as northern Minnesota and Florida.

Although all the consequences of acid deposition are not well understood, a growing body of evidence suggests that acid rain is responsible for substantial adverse environmental effects. These include the acidification of lakes, rivers and groundwaters, injury to aquatic species, acidification and demineralization of soils, reduction of forest productivity, damage to crops, and deterioration of buildings and man-made materials. In addition, the effects of acid rain on metallic elements in soil, aquatic ecosystems, and drinking water systems may affect human health adversely.

Current EPA authority generally focuses on control of the groundlevel concentrations of the precursor pollutants of acid rain. Control of these concentrations will not necessarily impact the level of acid rain which is more a function of the total precursors emitted into the air in a region over an extended period of time.

In order to reduce SO_2 and NO_x emissions, EPA in cooperation with the Department of Energy, is evaluating alternative emissions reductions strategies. These strategies focus primarily on utility and industrial boilers.

During the past year EPA has become increasingly involved in an environmental and economic issue popularly referred to as "acid rain." More accurately described as acid deposition (which includes wet and dry deposition of acidic particles, and acid mist, dew and fog) the issue is comprised of several current and potential problems, all of which are related to the emission, transportation, and atmospheric deposition of acidic or acid-forming chemical compounds. These problems include:

- o Damage to aquatic ecosystems, especially in the northeastern U.S., with associated economic losses;
- o International political tensions resulting from the damage to south-eastern Canada's lakes and streams caused by U.S. air emissions;
- o Visibility degradation caused by fine acidic sulfate and nitrate particles; and
- o Potential health effects attributable to the inhalation of fine acidic particles;
- o Potential large-scale and long term economic losses due to acid-caused damage to agricultrual crops and timber.

In addition to specific concerns about acid rain, States are beginning to look hard at the general issue of interstate pollution due to long-range transport of pollutants and particularly transport of sulfur dioxide and ozone. States are concerned about interstate equity, with upwind States arguing that more relaxed emissions limits in downwind States can lead to economic loss and reduced industrial growth in the upwind States.

Despite the existing uncertainties related to the specific effects of acid deposition, and the relationship between specific sources and those effects, some information has been generally accepted:

- o The high levels of acidity in the U.S. and Canada are caused by man-made sources of NO_x and SO_2. Since 1940 SO_2 emissions have grown by almost 40%; NO_x emissions have nearly quadrupled. The main source of SO_2 is power plants, emitting about 70% of all SO_2 nationally. The main sources of NO_x are power plants and motor vehicles, emitting about 30% and 40% respectively;
- o Emissions trends to the end of this century are difficult to estimate since emissions of SO_x and NO_x are subject to a number of variable factors: changes in control requirements, improvements in control technologies, rates economic growth, etc. However, Total emissions of SO_x may begin to rise again. Emissions of NO_x are likely to continue to increase through 2000, since the number of transportation vehicles will rise, and NO_x emissions from utility and industry sources are more difficult to control than SO_x emissions;
- o Available data indicate that during the last 40 years rainfall acidity has intensified in the eastern U.S. and spread southward and westward, much like the measured deterioration in U.S. visibility.
- o Low pH rainfall currently is widespread in the U.S., with pH levels of 4.0 to 5.0 common in most of the east and in parts of the west upwind of major urban areas. Eastern acidity is dominated by SO_2 emissions, while western acidity is dominated by NO_x emissions;
- o Aquatic ecosystem damage already has resulted from increases in surface water acidity. Over 200 lakes (about 50% of all lakes above 1000 feet) in the Adirondack Mountains can no longer support fish life; many Canadian lakes have been affected similarly, and the Canadians are claiming that 48,000 Canadian lakes are threatened. A trend toward increasing surface water acidity has been recorded in several regions in the eastern North America.

- o Acid deposition has been linked to other concerns such as the build-up of heavy metals in fish, the corrosion of drinking water pipes, and the corrosion or deterioration of metals and masonry such as that used in bridges buildings, cars, etc.

In order to address the major scientific uncertainties related to acid rain, EPA has developed an acid rain research program. That research program is focussed on:

- o Improved understanding of acid deposition patterns by (1) setting up a consistent monitoring network and (2) developing techniques to monitor dry deposition more accurately;
- o Improved understanding of the transport and transformation of pollutants which cause acid deposition; and
- o Improved understanding of the effects of acid deposition on aquatic life, crops, forests, building materials, drinking water, and human health.

In addition to the wide range of research projects already underway or planned, the agency also is co-chairing the Acid Rain Coordination Committee with the Department of Agriculture and the National Atmospheric and Oceanographic Administration. This committee has been established by law to plan and coordinate a Federal interagency research. This program, originally established by President Carter in August 1979, calls for a minimum of $10 million a year to be dedicated to acid deposition research over the next 10 years.

EPA recently completed a review of its current regulatory authority for addressing the acid rain problem. That review included the analysis of the following options:

- o Developing regulations under Sections 110(a)(2)(e) and 126 to implement the prohibition in those sections against interstate air pollution that prevents attainment or maintenance of national standards.

- o Requiring a more detailed demonstration of the amount of stack height for which sources may take credit in calculating emissions limitations (Sections 123).
- o Requiring continuous source monitoring.
- o Applying more vigorous modeling techniques to SIP revisions proposing emissions increases.
- o Establishing criteria and standards for currently unregulated pollutants (e.g., sulfates) that contribute to acid precipitation.
- o Prescribing procedures requiring States to establish technology based standards of performance for existing sources of non-criteria pollutants Section 111(d).
- o Making a finding under Section 115 that air pollutants in this country are endangering health or welfare in Canada and requiring SIP revisions to eliminate the endangerment.

EPA has concluded that although action under these existing authorities might reduce emissions that produce acid rain, neither the statute nor current EPA regulations were intended to deal with the unique problems associated with reducing acid rain and long range transport of air pollution. As a result, any EPA action under existing authorities would result in only a limited emissions reduction and/or be accomplished over a period of up to ten years. Moreover, any action would lead to lengthy litigation further delaying implementation.

EPA has therefore begun an assessment of the costs and effects of alternative acid rain control options requiring new legislative authority. This assessment, funded jointly by EPA and DOE has included two utility simulation models and industrial and mobile source emissions models. These models are being run for scenarios which reflect variouis types of regulatory strategies (emission caps, bubbles, taxes, and technology

standards) at alternative levels of emissions control stringency. Because the utility sector is the predominant source of acid deposition precursor emissions, the model runs focus primarily on emissions controls in the utility sector. However, the models, which are ultimately intended to show the impact of alternative control programs on acidic pollutant deposition patterns, can be used to demonstrate the impact of mobile and industrial source controls as well as those imposed on the utility sector.

To date the analysis has been laid out to examine the effects of the following types of controls in the utility sector:

(1) Emissions caps: each power plant is required to emit at a rate less than some prescribed rate. The rates being examined are 2 and 4 lbs. of SO_2 and 0.7 lbs. of NO_x per million BTU of heat input.

(2) Bubbles or Areawide Least Cost Solutions: each specified region is allowed to attain an emissions reduction target at least cost. The emissions reduction target and the size of the region are varied.

(3) Emissions Control Technologies: each plant is required to employ a technology capable of attaining a stated level of emissions reduction. The primary focus of these runs will be coal washing but will also include advanced NO_x controls and SO_2 scrubbers.

(4) Emissions Taxes: emissions will be taxed at alternative levels. Additional runs will include alternative tax floors and a sliding scale approach which increases the tax as emissions increase.

The results of these analyses will allow EPA to examine the economic and environmental implications of a large number of alternative approaches to the control of acid deposition precursor emissions.

Although the analysis has been structured primarily to yield information on the effect of different regulatory structures and stringency levels, the

analysis will also yield useful information on the effects of regulatory timing (some runs delay regulatory action until advanced technologies are assumed to be available) and on the cost of regulatory strategies which seek to prevent the displacement of high sulfur coal miners.

The study these the alternative regulatory programs is not scheduled for completion in May 1981.

Because of the present uncertainties related to the causes and effects of acid deposition, EPA will provide the Nation with the results of its analysis rather than recommend a particular course of action to deal with acid rain and the broader problem of long range transport of air pollution. The agency will coherently describe (1) its understanding of the extent of known and suspected environmental damages and their costs (2) its concern about future environmental and health damages, (3) the research program in place to answer the many questions concerning acid rain formation and effects, (4) the insufficiencies in the agency's current authority to control acid rain precursor emissions, (5) the range of alternative control strategies available to deal with the problem and legislative amendments to implement them, and (6) the connection between acid rain, long-range air pollution transport across both state and international borders, interstate equity concerns and the legislative proposals necessary to deal with this complex of issues.

This approach will give the Nation the information it needs to set one of basically three fundamental courses of action:

(1) Determination that not enough is known about the causes and effects of acid rain to implement any regulatory control program, but that an acid rain research program should be carried out at its present level or some accelerated level;

(2) Determination that there are known acid rain related damages and

substantial concerns about additional future damages, but that the uncertainties concerning cause and effect are too great to justify an extensive control program. This course of action would emphasize continued research and some modest emissions reductions program to "hold the line" on emissions growth; or

(3) Determination that because existing and potential economic and environmental damages due to acid rain are severe and irreversible, a strong regulatory program is necessary. This approach would emphasize the authority EPA would need to carry out a regulatory program to reduce emissions in the most cost-effective manner.

STATE OF CALIFORNIA PERSPECTIVE ON NO_x CONTROL FOR STATIONARY SOURCES

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ABSTRACT

The California NOx control program is directed toward the achievement and maintenance of air quality standards not only for nitrogen dioxide, but also for ozone, total suspended particulate and visibility. In addition to stringent controls on mobile sources, controls on existing stationary sources and best available control technology (BACT) on new sources are needed in non-attainment areas. In these non-attainment areas, the state is encouraging local districts to adopt controls on refinery boilers and heaters, industrial boilers, gas turbines, stationary I.C. engines, glass plants and cement plants, in addition to existing controls on power plants. The state considers selective catalytic reduction (SCR) to be BACT for most natural gas and oil fired combustion sources, and that (SCR) will be BACT for coal-fired power plants. We also believe that combustion modification techniques can be improved so that SCR may be unnessary on some sources.

If this meeting had been held in Los Angeles instead of the beautiful City of Denver, most of you who live outside of Los Angeles would probably have wondered to themselves whether or not it would be smoggy in Los Angeles during the meeting. Furthermore, those of you who work at reducing air pollution would probably have the feeling that you are doing something to reduce the smog problem.

Los Angeles and other California cities have severe air pollution problems. I want to talk to you today about that air quality problem and what the California State Government is doing about it.

The federal annual average air quality standard for nitrogen dioxide of 100 micrograms per cubic meter or 0.053 part per million has been violated for many years in the South Coast Air Basin or as it is otherwise known the Los Angeles Metropolitan Air Quality Control Region. The State of California one hour standard for nitrogen dioxide of 0.25 part per million is also violated in the South Coast Air Basin. In Kern County, in California, ambient concentrations of nitrogen dioxide have also

been steadily increasing and almost approaching the air quality standards for nitrogen dioxide as a result of the installation of many hundreds of steam generators used to produce heavy oil by steam injection into the reservoir.

As most of you probably know, oxides of nitrogen also participate in the photochemical process which produces oxidants, among which is ozone. The ozone standard is widely violated in many areas in California, particularly in the South Coast Air Basin. While it is generally considered that control of emissions of hydrocarbons are necessary to achieve the ozone standard, it can also be shown that control of emissions of oxides of nitrogen can result in reduction in ozone concentrations under some circumstances and particularly in rural areas.

Oxides of nitrogen are also converted, in part, to nitrates in the atmosphere and form one of the constituents of total suspended particulate. This is generally known as secondary particulate. In the South Coast Air Basin, and in most urban areas, conversion of sulfur oxides, oxides of nitrogen and hydrocarbons to particulate accounts for a major part of the total suspended particulate. The federal and state annual average and 24-hour standards for total suspended particulate are also widely violated in many areas particularly in the South Coast Air Basin and other urban centers.

Achievement of the standards for TSP could not be made unless the precursors of the secondary particulate portion of the total TSP were controlled. For this reason, we believe that NOx control is necessary to achieve the TSP standards, particularly in urban areas.

The secondary particulate is very effective in reducing visibility since the particles are close to the light scattering size range. Therefore, NOx control is one of the essential steps that must be taken in order to improve visibility.

In California, the program to control NOx is separated into two elements: mobile source control and stationary source control. The California Air Resources Board has the primary responsibility for controlling emissions from mobile sources and the local air pollution control districts have the primary responsibility for controlling emissions from stationary sources. However, the Air Resources Board is required by law to ensure that the local air pollution control districts adopt and enforce measures needed to achieve the state and federal air quality standards. If the local air pollution control districts do not adopt such regulations, the Air Resources Board is empowered to adopt the necessary regulations for the local districts.

The Clean Air Act provides that the State of California can receive a waiver from the EPA vehicular emissions standards to adopt more stringent standards. The Air Resources Board has adopted more stringent standards for NOx emissions than has EPA. However, our ability to reduce NOx emissions further from vehicular sources has just about reached its limit, given the state of the art. To achieve the ambient air quality standards, it will be necessary to further reduce emissions from existing stationary sources and to require offsets for emissions from new stationary sources.

All of the air pollution control districts in which the large coastal, ocean water cooled power plants are located have adopted regulations to limit emissions of oxides of nitrogen from power plants to 225 ppm when burning oil and 125 ppm when burning natural gas. There is some variation from these levels, particularly for smaller power plants. In addition, in the South Coast Air Quality Management District emissions from large industrial boilers are also limited to 225 ppm when burning oil or coal and 125 ppm when burning natural gas. Of particular importance to utilities in the South Coast Air Basin, a regulation has been adopted which requires further reduction in power plant NOx emissions.

This rule, which is presently stayed and will be reconsidered at a hearing at Los Angeles next month, introduces the new concept of setting limits on total system-wide emissions in the air basin,

rather than setting limits on emissions from individual units. This concept, which is similar to EPA's bubble concept, allows a utility to reduce emissions at the lowest cost. The rule, which is probably the most stringent in the United States, requires a 90 percent reduction in total system-wide emissions from levels that would have occurred if all of the units had been burning oil. This reduction must be achieved by 1988 or 1990, depending on the option chosen. It also requires the two large utilities, Southern California Edison and the Los Angeles Department of Water and Power, to demonstrate by the end of 1982, on the equivalent of 100 megawatts or more of capacity, equipment designed to achieve a ninety percent reduction in NOx emissions. To comply with that requirement, Southern California Edison plans to start installing selective catalyic reduction equipment soon to treat one half of the flue gas stream on a 215 megawatt unit at its Huntington Beach plant. A paper to be delivered at this meeting will discuss that installation.

The rule contains four options for compliance. The first two options have two stages of reduction. The first option requires about a 50 percent reduction from oil burning emission levels by the end of 1983, and a 90 percent reduction by 1990. The second option requires about a 40 percent reduction from oil

burning emission levels by the end of 1983, and a 90 percent reduction by 1988. The third option, which was basically proposed by the Los Angeles Department of Water and Power, has a single stage of reduction, 90 percent by 1990.

The fourth option, which was basically proposed by the Southern California Edison Company requires an evenly stepped reduction in annual average emissions each year until 90 percent is achieved in 1990 plus a 75 percent reduction in peak emissions. The last two options require installation of controls as early as feasible. All of these options allow the reduction in emissions by any method, including reduced burning of natural gas and fuel oil. For example, if a nuclear power plant were brought on line, it would be considered as replacing oil and gas burning and therefore, would be a way of reducing NOx emissions. However, it is anticipated that selective catalytic reduction will be required on some units to meet the final requirements of the rule. We believe that selective catalytic reduction is a proven method of controlling NOx.

In Kern County, where I previously mentioned the increasing concentrations of nitrogen dioxide, a rule has been adopted which limits emissions of oxides of nitrogen from oil field steam generators. That rule has several innovative features. Firstly, it has three stages or levels of control. The first stage of 0.3 pound of NOx per million Btu of heat input must be met by July 1,

1982. The second stage of 0.25 pound of NOx per million Btu of heat input is only applicable if the ambient concentration of nitrogen dioxide reaches 0.20 ppm on a one-hour average or 0.045 parts per million on an annual average. The third stage of 0.14 pound of NOx per million Btu of heat input is only applicable if the ambient concentration of nitrogen dioxide reaches 0.25 parts per million on a one-hour average or 0.053 parts per million on an annual average. If the second and third stages are not triggered by air quality changes, emissions reductions made to meet the first stage of the rule can be banked and used as offsets. Furthermore, emissions may be averaged over the central or the western areas of the county such that the total emissions from all existing steam generators shall be no more than if each steam generator were in exact compliance with the rule. It is expected that the first and second stages of the rule can be achieved by the use of combustion modifications. The oil companies and the burner manufacturers have been taking aggressive steps to develop means to comply with this rule. In particular, North American Manufacturing, the supplier of most of the burners used in the steam generators in Kern County, has developed a combustion modification which results in reduction of NOx to well below the requirements of the first and second stages of the rule. The North American combustion modification package is being tested on three separate steam generators, one

each at three large oil producers. The cost of the control package has been reported to be less than $35,000. At the current oil prices, the saving in the cost of fuel in two years would be more than the cost of the equipment. Also, it is our information that more than 100 units are on order. If the third stage of the rule is triggered by an air quality change, it is anticipated that unless further reductions are achieved with combustion modifications, Thermal DeNOx may be required on some steam generators in order to comply with the emissions limit of 0.14 pound per million Btu of heat input.

Concern has been expressed that the use of low NOx burners and Thermal DeNOx in tandem may result in problems of: 1) the temperature in the transition section of the boiler changing because of the reduced excess air requirements of the low NOx burner and 2) the emitting of a blue plume because of the formation of ammonium sulfate in the scrubber. To investigate these problems, Getty Oil Company is conducting a year-long experiment on a 50 million Btu per hour scrubber-equipped steam generator which will be equipped with a low NOx burner and Thermal DeNOx.

To effect further NOx reductions required to meet the air quality standards, the Air Resources Board is working with local air pollution control districts for measures to control emissions from refinery boilers and heaters, industrial boilers, utility

gas turbines, internal combustion engines, glass plants and cement kilns. For refinery heaters we are looking at a limit of about 0.06 pound of NOx per million Btu of heat input, which is a reduction of about 50 percent. We expect that the limit for existing refinery and industrial boilers will be about 0.1 pound of NOx per million Btu of heat input. We believe that such levels can be achieved by the use of combustion modification techniques. For utility gas turbines, we believe limits of 0.18 to 0.28 µg/Joule (25 to 40 ppm) could be achieved by the use of water injection but in the long range we anticipate that catalytic combustion will be developed so that NOx can be controlled to very low levels. For internal combustion engines, we have proposed a limit of 0.75 grams per horsepower hour, a limit which would probably require SCR or other catalytic means. Our investigations indicate that NOx can be reduced from glass plants by modification of combustion additional electric boost, new furnace designs and flue gas treatment including Thermal DeNOx, SCR and potentially wet scrubbing. It is anticipated that either singularly or in combination, these control techniques will enable the Glass Industry to control NOx emissions by 60 to 70 percent from uncontrolled levels. Work on development of measures to control NOx emissions from cement kilns has just begun with a workshop being held on October 8 in Los Angeles.

Major new sources in non-attainment areas are required to use Best Available Control Technology to control NOx and in addition to offset any emissions by reducing emissions from other existing facilities. In our opinion, SCR is well proven for natural gas and oil fired boilers and heaters.

Except for an 830 million Btu per hour heat input boiler operated by Kerr McGee, there are no coal-fired power plants in California. To meet future requirements, Pacific Gas & Electric Company has proposed the construction of two 800 megawatt coal-fired units in Northern California. In addition, Southern California Edison and others have proposed the construction of three 500 megawatt coal-fired units in Southern California. We are pressing for the installation of selective catalytic reduction on these units. We believe that by the time these units go into operation in the late eighties, SCR will have been proven on coal-fired power plants in Japan.

As you can see, we have a very aggressive NOx emission control program in California, probably the most aggressive in the nation. Many of you may feel that we are expecting too much, but history has shown us that industry can rise to meet the challenge of stringent regulations. We are deeply appreciative to those of you here who have designed and developed ways to reduce emissions of oxides of nitrogen and other pollutants and those of you in industry who have led the way to get these methods or devices proven in practical operations. We still need your help. There is a lot to be done. Thank you for your attention.

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